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ABSTRACT

This study was designed to assess the effectiveness of three treatments for encouraging and training prospective elementary science teachers in the use of inductive/indirect strategies in science teaching. Subjects were randomly assigned to one of four treatment groups: (1) Strategy Analysis Level - subjects were trained in science teaching strategy analysis using the Teaching Strategies Observation Differential (TSOD); (2) Modeling Level - subjects viewed video-tapes of model science lessons which represented inductive/indirect teaching strategies; (3) Combination Level - subjects received treatments (1) and (2); and (4) Control Level - subjects viewed films neutral to the treatments. Data were collected using the TSOD, the Elementary Science Activities Checklist (ESAC) and the Science Activities Attitude Sort (SAAS). Results showed that the Combination Group adopted a more inductive/indirect science teaching style than those subjects in the Control Group. Evidence is provided indicating activities that will significantly and positively affect the science teaching style and attitude of pre-service elementary teachers can be designed. (Author/MH)

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SOME EFFECTS OF TRAINING PRESERVICE TEACHERS IN SCIENCE TEACHING STRATEGY ANALYSIS

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INTRODUCTION

The development of interaction and strategy analysis systems has spurred a fair amount of research on the relationships between the level of interaction within classrooms and such variables as student achievement and attitude toward the class. The results of much of this research can be summarized by saying that differences in achievement and attitude seem to be in favor of or related to indirect teaching strategies, (e.g., Shymansky and Matthews, 1974, Wolfson, 1973, Amidon and Flanders, 1970, La Shier and Westmeyer, 1967). If one places faith in these findings, it would seem that the literature carries a mandate for pre-service education classes to encourage and train teachers in the use of indirect teaching strategies.

The concept of directness or indirectness of teaching stragegy has been represented by Anderson, et al (1974) using the following behavioral hierarchy:

Direct Verbal

1. Exposition of facts (lecture)
2. Giving directions or opinions
3. Asking limiting questions

Direct Non-Verbal

4. Demonstrations
5. Student exercises ("cook book")

Indirect Verbal

6. Asking open-ended questions
7. Teacher response to student questions
8. Teacher guidance and probing

Indirect Non-Verbal

9. Teacher planned open ended investigations

10. Student planned investigations

PURPOSE

This study was designed to assess some of the effects of three treatments designed to encourage and train prospective elementary science teachers in the use of indirect strategies in science teaching.

PROCEDURE

The subjects of the study were enrolled in the undergraduate pre-service education program in the School of Education at the University of Colorado, Boulder. All student teachers who were assigned to teach in grades 3, 4, 5 and 6 were stratified according to grade level taught. Sixteen subjects from each grade level then were randomly selected and assigned to each of three treatments and a control group for a total of 64 elementary pre-service teachers in the study. The random sample included 71 females and 13 males which adequately reflected the composition of the available population.

At the time of the treatment, all subjects were enrolled in a block of self-paced education and teaching methods courses. During the data collection phase of the study, all of the subjects were engaged in student teaching in the Boulder Valley School District in Colorado.

Treatment Levels

Four one-hour discussion sessions near the end of the fall semester and one one-hour session during the week preceding the spring student teaching assignment were used to administer all treatment levels.

Level 1, The Strategy Analysis Level (S)

Subjects in this group were trained in strategy analysis and planning. During these sessions an instructor presented the strategy levels as defined by the Teaching Strategies Observation Differiental (TSOD) as proposed by Anderson, et al (1974). The purpose of the presentation was to insure that the students had an understanding and awareness of possible science teaching strategies as proposed by the TSOD. These sessions also included a discussion of evidence from research on the effects of classroom interaction on pupil achievement and attitude. The compilation of the evidence included the research cited earlier in this paper and was used in an attempt to persuade the subject to accept the inductive/indirect strategy as a desirable method of teaching science. The method used to present this evidence was a lecture-discussion format.

In addition, the subjects in this treatment were divided into small groups and given a set of behavioral objectives from the Science--A Process Approach materials. They were asked to plan a lesson that (a) would include the level of the different TSOD strategies that they would use to help the students meet the stated objectives and (b) would be conducted in the amount of time they desired to spend at each strategy level.

Level 2, The Modeling Level, (M)

The treatment administered to subjects in this group consisted of the presentation of a series of four video-tapes and one 16mm film of

elementary science teaching which represented inductive/indirect strategy. The video-tapes consisted of lessons taught in the 4th, 5th and 6th grades by two graduate students who had previous teaching experience and understood the concept of teaching strategies and could apply them in a classroom setting. Below is a list of the model lessons, their source and the level of strategy, as rated on the TSOD:

1.	"Batteries and Bulbs"	ESS	4.6
2.	"Ball and Ring"	IDP	6.5
3.	"The Pulse Glass"	IDP	6.7
4.	"The Whirly Bird"	SCIS	8.1

The 16mm film selected for the treatment was the SCIS (1969) film, Don't Tell Me--I'll Find Out.

No organized discussion followed the presentation of the tapes or film, but a period of time was allowed for whatever discussion or questions the subjects initiated. This group did not receive training in strategy analysis nor any research findings related to it.

Level 3, The Combination Level, (MS)

Subjects in this group were involved in all the activities from the two levels above, i.e., training in strategy analysis and planning, discussion of the research and viewing models of elementary science teaching. The model lessons were viewed while the subjects were being trained in the use of the TSOD. Representative segments from each model lesson were actually rated by the subjects.

Level 4, The Control Group, (C)

Subjects assigned to this group were scheduled to spend their time in an activity considered to have a neutral relationship to the treatment levels described above, i.e., viewing science content films which did not present model lessons or teaching strategies.

The amount of time spent in any of the sessions was essentially equal across all treatment levels.

HYPOTHESIS

The underlying hypothesis that guided the design of the treatment levels was that if one could help pre-service teachers to understand and become aware of the strategies related to science teaching and the positive effects that more indirect classroom interactions have on student outcomes, they would tend to be more inductive/indirect in their teaching.

DATA COLLECTION

Data were collected on the science teaching strategies of the student teachers, via video-tapes, after they had an opportunity to become established in the public school classroom and take over the science teaching responsibilities. Each subject was taped one time for at least 30 minutes. The scheduling of the taped lesson was by mutual agreement between the experimenter and the student teacher. No directions or inferences were given as to the type of lesson that should be taught during the video-taping session. Also, the subjects were ignorant of the fact that they were involved in an experimental study and all caution was taken to insure that they did not relate the data collection directly to the treatment sessions.

The sessions recorded via video-tape in the classroom were then analyzed by trained raters, using the TSOD, in such a way that they were blind to experimental and control subjects. Two raters rated

each tape and the average was considered as the level of strategy for that subject. The inter-rater reliability was .99.

The Elementary Science Activities Checklist (ESAC) was used for the purpose of measuring the elementary school pupil's perception of their student teachers, science teaching strategies. The ESAC was adapted from Kochendorfer and Lee (1967) and is a checklist of items which might occur in an elementary science class. Six science educators examined the list to determine which of the items described activities which were indicative of inductive/indirect teaching strategies. The items in this category were given the weight of 1 and items that indicated expository/direct strategies were weighted 0. The reliability of the ESAC was .76.

Data relating to the pre-service teacher's attitude toward the role of the pupil in Science class were collected at the last treatment session through the use of the Science Activities Attitude Sort (SAAS). This instrument includes forty statements describing student roles and activities that range from extremes of student-centered to teacher-centered concepts. Subjects were asked to sort the statements into a forced normal distribution based on stanine percentages. The raw score of each individual is in the form of an r_{xy} coefficient based on the amount of correlation between the individual's sort and an "ideal" sort. The "ideal" sort for the SAAS is an ordered set of the concept statements on student roles based on the average rank given to the statement by a jury of natural and social science educators who were instructed to rank the statements from those representative of inductive/indirect activities to those representative of expository/direct activities. The reliability of the SAAS was .64.

Data also were collected on the average class IQ and class size for each student teacher.

RESEARCH DESIGN

The basic design for this study can be diagrammed in the Campbell and Stanley (1971) notation as follows:

R	X_1	O_1	O_2	O_3
R	X_2	O_1	O_2	O_3
R	X_3	O_1	O_2	O_3
R	X_4	O_1	O_2	O_3

The levels of the treatment variable, each of which have been discussed previously, are:

X_1 The Strategy Analysis treatment level - (S)

X_2 The Modeling treatment level - (M)

X_3 The Combination treatment level - (SM)

X_4 The Control treatment level - (C)

The criterion measures, each of which also has been discussed previously, are:

O_1 Science Activities Attitude Sort - (SAAS)

O_2 Teaching Strategy Observation Differential - (TSOD)

O_3 Elementary Science Activities Checklist - (ESAC)

STATISTICAL HYPOTHESES

The following statistical hypotheses were tested for effects on the three criterion variables due to treatment:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$$

$$H_1: \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$$

In the above, μ_1, μ_2, μ_3, and μ_4 are the population means associated with treatments X_1, X_2, X_3 and X_4 from the Campbell and Stanley notation.

The following hypotheses relating to the main effect of grade level taught on the three criterion variables and treatment by grade level interaction were tested.

H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

H_1: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$

H : there is no grade level by treatment interaction

In the above, μ_1, μ_2, μ_3 and μ_4 are the population means associated with grades 3, 4, 5 and 6. The decision to factor out grade level was based on a study by Irwin and Butts (1972), who in reporting conclusions based on their own and the research of others, stated that significant relationships might exist between student age and interaction patterns of teachers.

Significance levels for all hypotheses testing in this study were purposely set a priori at .10 as an acceptable risk of type 1 error (i.e., there was a 90 percent probability that the correct decision was made when a null hypothesis was rejected) and as a method for increasing statistical power. No tables are available to determine the exact power of the F test when alpha = .10. But if the conventional alpha level of .05 would have been selected for this study, the power of the F test would have been approximately .50 (i.e., there would have been only a 50 percent probability that the correct decision was made when one failed to reject a null hypothesis). Relaxing alpha to .10 substantially increased this probability.

ANCOVA was employed as the statistical test for group differences on the TSOD measure and also for group differences in the class average on the ESAC. Class size and average class ability were selected as concomitant variables. ANOVA was used to detect differences on the SAAS for the student teachers' perceptions of the role of the student. As with

the TSOD and the SAAS, the sampling unit for the ESAC was the class. This decision was made because the random selection was made at the teacher level and also as a guard against a violation of the assumption of independence of data needed for the ANCOVA and ANOVA. (Peckham, Glass and Hopkins, 1969) An a priori decision was made that if a significant difference due to treatment was found among the means with the omnibus F test, the Newman-Keuls multiple comparison technique would be used to test hypotheses 4, 5 and 6 of the following null hypotheses:

1. H_0: $\mu_1 = \mu_4$ H_1: $\mu_1 > \mu_4$
2. H_0: $\mu_2 = \mu_4$ H_1: $\mu_2 > \mu_4$
3. H_0: $\mu_3 = \mu_4$ H_1: $\mu_3 > \mu_4$
4. H_0: $\mu_2 = \mu_3$ H_1: $\mu_3 \neq \mu_3$
5. H_0: $\mu_2 = \mu_1$ H_1: $\mu_2 \neq \mu_1$
6. H_0: $\mu_3 = \mu_1$ H_1: $\mu_3 \neq \mu_1$

A Dunnett multiple comparison test, with μ_4 as the control, was to be performed on hypotheses 1, 2 and 3, even if the omnibus F test indicated no significant differences among the means. The justification for this decision rested on the choice of a directional test along with the relaxed alpha as a method to increase statistical power. In this study, the main concern was to identify a treatment that can produce a movement toward the use of inductive/indirect strategy and an attitude shift toward a perception of the student's role as active and central in relation to the educational activities. Therefore, this writer believes the a priori decision to make directional hypotheses tests of all group means against the control group to be justified.

RESULTS OF THE STUDY

Hypothesis Tests Using the TSOD Data

The set of null hypotheses related to the effect of the treatment levels on the science teaching strategies of elementary pre-service teachers are as follows:

1. There are no differences in science teaching strategies, as measured by the TSOD, among the treatment groups which experienced the four different levels of treatment associated with strategy analysis and planning in science classes.
2. There are no differences in the science teaching strategies employed by elementary pre-service teachers, as measured by the TSOD, due to the effects of grade level taught.
3. There is no interaction between the type of training in strategy analysis received and the grade level taught as expressed in the dependent variable, science teaching strategy.

The TSOD unadjusted cell and marginal means associated with Hypotheses 1, 2 and 3 are presented in Table 1.

Table 2 shows the results of a two-way analysis of covariance within a 4 x 4 factorial design, using class size and average class ability as covariates. The Finn multivariate analysis computer program (Finn, 1968) was used for the analysis of the data.

On the basis of the F ratios calculated on the main effect of grade level taught and also on the treatment level by grade level interaction, Hyoptheses 2 and 3 could not be rejected. An F value of 2.21 is required for rejection of a null hypothesis with 3 and 40 degrees of freedom at the 0.10 alpha level.

TABLE 1

Observed Cell Means and Marginal Means of TSOD Scores Across Treatment Levels and Grade Level Taught

Grade Level Taught	Level 1 (MS)	Level 2 (M)	Level 3 (S)	Level 4 (C)	Means
Grade 3	4.07	4.03	3.30	3.48	3.72
Grade 4	3.84	4.33	4.33	3.76	4.06
Grade 5	5.33	4.74	5.07	3.27	4.60
Grade 6	4.60	3.93	3.26	3.42	3.80
Means	4.46	4.25	3.99	3.48	4.05

$s = 1.18$ $s^2 = 1.39$ $s_{\bar{X}} = .295$

TABLE 2

Analysis of Covariance Summary Table for the TSOD Variable

Source of Variation	df	Sum of Squares	Mean Square	F
Treatment Level	3	9.15	3.05	2.16
Grade Level	3	6.75	2.25	1.59
Treatment by Grade Interaction	9	7.44	.827	.585
Within	46	65.04	1.414	

$.10F_{3,40} = 2.21$ $.10F_{9,40} = 1.79$

In relation to Hypothesis 1, the F ratio on the main effect of treatment level indicated that there was approximately a 90 percent probability that the null hypothesis was not true. Because the omnibus test presents this level of probability that a difference exists among the means of the treatment levels, further hypothesis testing needed to be done to determine the location of this difference. The following alternate hypotheses were generated a priori to the research and could now be tested:

1a. The average science teaching strategy as measured by the TSOD will be higher for the MS (combination) treatment group than for the C (control) treatment group.

1b. The average science teaching strategy as measured by the TSOD will be higher for the M (modeling) treatment group than for the C (control) treatment group.

1c. The average science teaching strategy as measured by the TSOD will be higher for the S (strategy analysis) treatment group than for the C (control) treatment group.

The above hypotheses were tested by a multiple comparison technique using the Dunnett multiple t test (Myers, 1972). Miller's (1966) discussion of the Many-One Univariate comparison is a reference to this same statistic.

The results of the post hoc testing (Table 3) identified a significant difference ($p < .05$) between the MS group and the control group; therefore, Hypothesis 1a was rejected while Hypotheses 1b and 1c remained tenable.

TABLE 3

Comparison of Treatment Group Adjusted Means with Control Group Adjusted Means on the TSOD

Means:	$\bar{X}_{MS} = 4.48$	$\bar{X}_{M} = 4.23$	$\bar{X}_{S} = 4.02$	$\bar{X}_{C} = 3.44$
	$H_0: \mu_{MS} = \mu_C$ $H_1: \mu_{MS} > \mu_C$		$t = 2.46$ $(p < .05)$	
	$H_0: \mu_M = \mu_C$ $H_1: \mu_M > \mu_C$		$t = 1.88$ $(p > .10)$	
	$H_0: \mu_S = \mu_C$ $H_1: \mu_S > C$		$t = 1.38$ $(p > .10)$	
	$.10t_{40,k=4} = 1.9$		$.05t_{40,k=4} = 2.13$	

Further data analysis was needed to test the following null hypotheses which were also a priori considerations in the study:

There are no differences in the science teaching strategies, as measured by the TSOD, between the following levels:

1d. MS treatment versus M treatment

1e. MS treatment versus S treatment

1f. M treatment versus S treatment

The above hypotheses were tested through the use of the Newman-Keuls multiple comparison technique (Myers, 1972). This technique was selected as a method to make pair-wise contrasts which are beyond the restrictions of the Dunnett test (Hopkins and Anderson, 1973). Decisions

with the Newman-Keuls technqiue are based on the probable distribution of the q statistic (Rohlf and Sokal, 1969). A q of 2.99 is required for rejection of a null hypothesis with 40 degrees of freedom and j = 3 at the 0.10 alpha level. Results of the post hoc tests related to Hypotheses 1d, 1e and 1f are given in Table 4. The calculated q value for Hypothesis 1d did not equal or exceed the critical value needed for rejection of the null hypothesis at the established significance level. Therefore, under the restrictions of the Newman-Keuls test Hypotheses 1d, 1e and 1f remained tenable.

TABLE 4

Other Comparisons of the Treatment Group Adjusted Means of the TSOD

Means:	$\bar{X}_{MS} = 4.48$	$\bar{X}_{M} = 4.23$	$\bar{X}_{S} = 4.02$	$\bar{X}_{C} = 3.44$
H_0: $\mu_{MS} = \mu_M$		$q = .318$ ($p > .10$)		
H_1: $\mu_{MS} \neq \mu_M$				
H_0: $\mu_{MS} = \mu_S$		hypothesis not testable		
H_1: $\mu_{MS} \neq \mu_S$				
H_0: $\mu_M = \mu_S$		hypothesis not testable		
H_1: $\mu_M \neq \mu_S$				

$.10^{q}_{40,j=3} = 2.99$

Figure 1 is a summarization of the results of the post hoc testing on the TSOD data. From this figure, it is evident that the elementary

pre-service teacher who received training in the MS treatment group had higher TSOD scores than those teachers who received no training in teaching strategies. No non-chance differences on the TSOD measure seemed to exist between any of the other treatment groups.

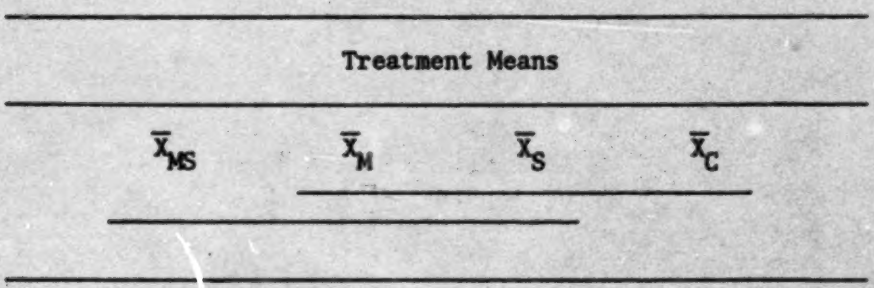

Fig. 1. A Multiple Comparison Summary Figure on the TSOD Data*

*Any two means not underlined by the same line differ significantly. ($p < .10$)

Hypothesis Tests Using the ESAC Data

The set of hypotheses related to the effect of the treatment levels on the science teaching strategies of elementary pre-service teachers, as perceived by the elementary pupil, are as follows:

4. There are no differences in the science teaching strategies, as perceived by elementary pupils and measured by the ESAC, among the treatment groups which experienced the four different levels of treatment associated with strategy analysis and planning in science classes.
5. There is no difference in science teaching strategy, as perceived by elementary pupils and measured by the ESAC, due to the effects of grade level taught by the elementary pre-service teachers.

6. There is no interaction between the type of training received in strategy analysis and the grade level taught as expressed in the dependent variable, score on the ESAC.

The ESAC unadjusted cell and marginal means associated with Hypotheses 4, 5, and 6 are presented in Table 5.

TABLE 5

Observed Cell Means and Marginal Means of ESAC Scores Across Treatment Levels and Grade Levels Taught

Grade Level Taught	Level 1 (MS)	Level 2 (M)	Level 3 (S)	Level 4 (C)	Means
Grade 3	14.25	12.25	13.30	13.70	13.38
Grade 4	13.05	13.82	13.32	12.20	13.10
Grade 5	13.77	13.37	12.65	12.47	13.07
Grade 6	13.35	14.12	12.37	12.45	13.07
Means	13.61	13.39	12.91	12.71	13.16

$s = 1.39$ $s^2 = 1.93$ $s_{\bar{X}} = .347$

The results of an analysis of covariance within a 4 x 4 factoral design, using class size and average class ability as covariates, are shown in Table 6. On the basis of the F ratios calculated on the main effect of grade level taught and also on the treatment level by grade level interaction, Hypotheses 5 and 6 could not be rejected (Table 6). An F value of 2.21 is required for rejection of a null hypothesis with 3 and 40 degrees of freedom at the 0.10 alpha level.

In relation to Hypothesis 4, the F ratio on the main effect of treatment level indicated that there is approximately an 80 percent

TABLE 6

Analysis of Covariance Summary Table
for the ESAC Variable

Source of Variation	df	Sum of Squares	Mean Square	F
Treatment Level	3	8.92	2.97	1.58
Grade Level	3	1.40	.466	.248
Treatment by Grade Interaction	9	20.97	2.33	1.24
Within	46	86.53	1.881	

$.10F_{3,40} = 2.21$ $.10F_{9,40} = 1.79$

probability that the null hypothesis is not true. This probability level is misleading in that it is low when directional hypothesis testing has been specified. The omnibus F test, with more than two levels in a factor, is insensitive to decisions related to directional testing and provides probabilities associated with two-tailed tests. Since one-tailed tests were desired, this interpretation of the F statistic presented one with the probability, within the stated confidence limits, that a difference could exist among the means of the treatment levels. Therefore, further hypothesis testing was needed to determine the location of this difference. The following alternate hypotheses were generated a priori and could now be tested:

4a. The average science teaching strategy as perceived by the elementary pupil and measured by the ESAC will be higher for the MS (combination) treatment group than for the C (control) group.

4b. The average science teaching strategy as perceived by the elementary pupil and measured by the ESAC will be higher for the M (modeling) treatment group than for the C (control) group.

4c. The average science teaching strategy as perceived by the elementary pupil and measured by the ESAC will be higher for the S (strategy analysis) treatment group than for the C (control) group.

As with the TSOD data, the above hypotheses were tested through the use of the Dunnett multiple t test (Myers, 1972). The results of the post hoc testing (Table 7) identify a significant difference ($p < .10$) between the MS group and the control group; therefore, Hypothesis 4a can be rejected. Because no other differences proved to be significant, Hypotheses 4b and 4c must remain tenable. All other a priori hypotheses were non-directional; therefore, their probability of being rejected was assessed as being outside of the stated confidence limits by the omnibus F test.

Figure 2 is a summarization of the results of the post hoc testing on the ESAC data. From this figure it is evident that the elementary pre-service teachers trained in the MS treatment group received higher ESAC scores than those teachers who had no training in teaching strategies. No other non-chance differences existed.

Hypothesis Tests Using the SAAS Data

The null hypothesis related to the effect of the treatment on the subject's attitude toward the role of the pupil in science class is stated as:

TABLE 7

Comparison of Treatment Group Adjusted Means with Control Group Adjusted Means on the ESAC

Means:	$\bar{X}_{MS} = 13.64$ $\bar{X}_{M} = 13.37$ $\bar{X}_{S} = 12.96$ $\bar{X}_{C} = 12.26$	
	$H_0: \mu_{MS} = \mu_C$ $H_1: \mu_{MS} > \mu_C$	$t = 2.03$ $(p < .10)$
	$H_0: \mu_M = \mu_C$ $H_1: \mu_M > \mu_C$	$t = 1.47$ $(p > .10)$
	$H_0: \mu_S = \mu_C$ $H_1: \mu_S > \mu_C$	$t = .620$ $(p > .10)$

$.10t_{40,k=4} = 1.9$

Treatment Means

$\bar{X}_{MS}$ $\bar{X}_{M}$ $\bar{X}_{S}$ $\bar{X}_{C}$

Fig. 2. A Multiple Comparison Summary Figure on the ESAC Data*

*Any two means not underlined by the same line differ significantly. $(p < .10)$

7. There is no difference in the attitude toward the role of the pupil, as measured by the SAAS, among the treatment groups which experience the four different levels of treatment

associated with strategy analysis and planning in science classes.

The SAAS cell and marginal means associated with Hypothesis 7 are presented in Table 8; the one-way analysis of variance summary appears as Table 9.

TABLE 8

Observed Cell and Marginal Means of SAAS Scores Across Treatment Levels

Level 1	Level 2	Level 3	Level 4	Marginal Mean
.841	.777	.734	.685	.759

$s = .217$ $s^2 = .047$ $s_{\bar{X}} = .047$

TABLE 9

Analysis of Variance Summary Table for the SAAS Variable

Source of Variation	df	Sum of Squares	Mean Square	F
Between Groups	3	.277	.092	1.94
Within Groups	80	3.78	.047	

$.10F_{3,80} = 2.18$

The F ratio from Table 9 leads one to believe that there is approximately an 80 percent probability of Hypothesis 7 being false. Again, as stated earlier, this estimate is a minimal one based on two-tailed tests. As described previously, when some of the hypotheses are directional or

one-tailed, one must proceed with multiple comparison analyses of the data related to these hypotheses. The directional hypotheses planned around the SAAS variable are as follows.

7a. The attitude of the subjects in the MS (combination) treatment group will be more highly correlated with the ideal attitude than that of the C (control) group.

7b. The attitude of the subjects in the M (modeling) group will be more highly correlated with the ideal attitude than that of the C (control) group.

7c. The attitude of the subjects in the S (strategy analysis) group will be more highly correlated with the ideal attitude than that of the C (control) group.

As with the variables mentioned previously in this paper, the above paper, the above hypotheses were tested through the use of the Dunnett multiple t test (Myers, 1972). Results of the post hoc testing (Table 10) indicate that there is a significant difference ($p < .05$) between the MS group and the control group; therefore, Hypothesis 7a is rejected. Since no other differences showed significance, Hypotheses 7b and 7c remain tenable.

As with the ESAC data, all other a priori hypotheses were non-directional; therefore, their probability of being false was assessed as being outside of the stated confidence limits by the omnibus F test (Table 9).

Figure 3 is a summarization of the results of the post hoc testing on the SAAS data. From this figure it is apparent that the elementary pre-service teachers trained in the MS treatment group developed an attitude which was more highly correlated with the ideal attitude than those teachers who had no training in teaching strategies. No other non-chance differences appeared in the data.

TABLE 10

Comparison of Treatment Group Adjusted Means with Control Group Adjusted Means on the SAAS

Means:	$\bar{X}_{MS} = .841$	$\bar{X}_{M} = .777$	$\bar{X}_{S} = .734$	$\bar{X}_{C} = .685$
	$H_0: \mu_{MS} = \mu_C$		$t = 2.33$	$(p < .05)$
	$H_1: \mu_{MS} > \mu_C$			
	$H_0: \mu_{M} = \mu_C$		$t = 1.37$	$(p > .10)$
	$H_1: \mu_{M} > \mu_C$			
	$H_0: \mu_{S} = \mu_C$		$t = .738$	$(p > .10)$
	$H_1: \mu_{S} > \mu_C$			
	$.10t_{80,k=4} = 1.85$		$.05t_{80,k=4} = 2.10$	

Treatment Means

$\bar{X}_{MS}$ $\bar{X}_{M}$ $\bar{X}_{S}$ $\bar{X}_{C}$

Fig. 3. A Multiple Comparison Summary Figure on the SAAS Data*

*Any two means not underlined by the same line differ significantly. ($p < .10$)

SUMMARY OF THE HYPOTHESIS TESTING

An inspection and comparison of Figures 1, 2 and 3 shows that the effects of the treatment levels were consistent across the three dependent variables. The MS treatment, defined as the combination treatment and consisting of training in strategy analysis and planning with video-tapes as models of inductive/indirect lessons, proved to be significantly more effective than the other treatment levels in causing elementary pre-service teachers to use more inductive teaching strategies. These results were reinforced by data on teaching strategies collected from the pupils being taught by the subjects in the study. The MS treatment also proved to be the most effective in causing an attitude shift that was more akin to an attitude judged to be ideal. Table 11 is a summarization of the observed means associated with each of the dependent variables across all treatment levels. It can be noted from Table 11 that the MS treatment proved to be the most effective on all dependent variables. The trends associated with the treatment levels also are consistent across all dependent variables.

TABLE 11

Summarization of the Observed Means of the Dependent Variables Across Treatment Levels

	MS	M	S	C
TSOD	4.46	4.03	3.30	3.48
ESAC	13.61	13.39	12.91	12.71
SAAS	.841	.777	.734	.685

CONCLUSIONS

The results of this study provide evidence that it is possible to design activities which will significantly and positively affect the teaching style and attitude of elementary pre-service science teachers. It appears that the best method to bring about these changes is a combination of training in science teaching strategy analysis with the use of video-taped model lessons. The use of strategy analysis or the model lessons alone shows some promise, because of the consistent trends they produced on all the dependent variables.

If one can assume that elementary science teachers should be using higher levels of teaching strategies, as defined by the TSOD, then it is the recommendation of this researcher that a curriculum unit modeled after the MS treatment activities in this study be developed and incorporated as a teacher education activity.

SUGGESTIONS FOR FURTHER RESEARCH

It has been shown in this study that training in science teaching strategy analysis with video-taped model lessons does cause elementary pre-service teachers to adopt a more inductive/indirect teaching style and adopt a more ideal attitude toward the role of the pupil in science class. Further research is needed to increase the generalizability of this study. First, there needs to be more investigation into the effects of similar training on pre-service and in-service secondary teachers and also on in-service elementary teachers. Second, this type of study needs to be extended to all subject areas at both the elementary and secondary levels. Third, research needs to be done in a longitudinal

dimension to determine if the changes due to treatment in this study are retained beyond the student teaching experience. And fourth, since there is a trend toward individualized instruction in teacher education programs, some investigation is needed to determine if a similar treatment could be as effective when administered on an individualized, self-paced basis.

In relation to the attempt made by this researcher to factor out various treatment levels within the combination treatment, more research needs to be done with larger samples sizes to determine if the trends identified in this study are non-chance differences due to treatment.

Another recommendation, based on the cross-validation between the data collected via video-tapes and that solicited from elementary pupils, is that we need to put more faith in the ability of pupils to form a valid perception of the teaching act and use them more as a source of data on classroom activities. The energy and resources needed to collect data via video-tape could be spent more wisely in expanding the scope of the research in some of the other directions mentioned above.

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